During the formation of semiconductor devices, metallization layers are generally formed in trenches and openings to form interconnects and vias. Formation of such metal layers can sometimes be complicated by difficulties with the conductivity of the metallization layers and accordingly efficient methods for forming such metallization layers of good conductivity are sought.

The present invention addresses the problem by providing a method of forming a layer of metal on the substrate which comprises depositing a seed layer of metal **on a surface of Ti** at a substrate temperature of from 220 to 300°C followed by depositing a second amount of metal under temperature and power conditions sufficient to inhibit the formation of filamentous metal phases having a resistivity greater than that of said metal and providing a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0, followed by depositing a third amount of metal. Applicants discovered that a process in which a seed layer of metal is formed **on a surface of Ti** at a substrate temperature of from 220-300°C is effective in a method of forming a layer of metal on a substrate. More specifically, Applicants have discovered that such a seed layer allows for the deposition of metal on said seed layer at a substrate temperature and power that are sufficient to (i) inhibit formation of filamentous metal phases having a resistivity greater than that of said metal, and (ii) provide a metal diffusion rate and a metal deposition rate sufficient to inhibit void formation in an opening having an aspect ratio of at least 2.0; Such a method is nowhere disclosed or suggested in the prior art of record.

The rejection of Claims 1-20 and 22-24 under 35 U.S.C. § 103(a) over Xu U.S. 6,217,721 is respectfully traversed.

Applicants note, that the claims are directed to a method of depositing a seed layer of a metal, onto a first substrate surface which is Ti. The identity of the first substrate surface as

being Ti, is clear from the claim language of claim 1, which recites that the seed layer of metal is deposited **on a first substrate surface which is Ti**. Claim 9, which recites that the metal is Al also makes clear that the first substrate surface is Ti. Accordingly the examiner's interpretation of the claim as requiring the seed layer to be Ti, is **incorrect** (page 4 of outstanding official action). The examiner is respectfully requested to consider the claim, according to the plain and ordinary meaning of the claim terms, in which the first substrate surface is Ti. To the extent that this claim interpretation is contrary to any prior interpretations made by the examiner, further consideration of the present claim is respectfully requested.

Xu fails to disclose or suggest a method in which a high aspect opening is filled with a metal in which a Ti liner layer is used, and the seed layer is formed **at a temperature of from 220-300°C.**

Xu describes a method of cold deposition is illustrated at column 20, line 11, as Al sputtering at a substrate temperature of **only 130°C** or lower to form a seed layer. The reference teaches the preferred cold deposition temperature to be **200°C or below** as the dewetting temperature is 250°C (column 24, lines 58-60).

The examiner agrees that the cited reference teaches a temperature of **only 200°C**, however argues that a temperature of from 220 to 300°C as claimed would have been obvious as such a temperature would have been identified as the optimum or workable range, and only require routine experimentation (page 6, lines 4-13 of the outstanding official action).

Applicants respectfully submit that it would not have been obvious to have selected a temperature of 220 to 300°C, as the result of optimization, as 1) the reference teaches that the temperature should not exceed 200°C as dewetting occurs at higher temperature; and 2)

temperature is not identified as a result effective variable capable of being optimized for a particular result.

As to the first point, the reference identifies a preferred temperature of **200°C or below** as, at a temperature of 250°C, dewetting occurs. The teaching of a preferred temperature range of 200°C or below, with an express teaching of undesired consequences from exceeding the preferred temperature range does not provide any motivation to exceed the temperature range of below 200°C.

> However, while it may ordinarily be the case that the determination of optimum values for the parameters of a prior art process would be at least *prima facie* obvious, that conclusion depends upon what the prior art discloses with respect to those parameters. Where, as here, the prior art disclosure suggests the outer limits of the range of suitable values, and that the optimum resides within that range, and where there are indications elsewhere that in fact the optimum should be sought within that range, the determination of optimum values outside that range may not be obvious. We think it is not on the facts of this case (In re Sebek, 175 USPQ 93, 95 (CCPA 1972)).

The reference identifies the range of below 200°C as preferable for this process step and further identifies undesired results from **exceeding** the preferred range of 200°C. Contrary to the assertions in the official action, those of ordinary skill in the art would not be motivated to exceed a temperature of below 200°C, as the reference clearly identifies reasons not to exceed this temperature. Why would one be motivated to use a temperature which is suggested to increase the likelihood of dewetting? There simply is no motivation to increase to temperature in view of the express negative results from higher temperature. As a matter of patent law there is no motivation to exceed the identified range of below 200°C.

As to the second point, it is suggested by the examiner that the claimed temperature range of 220 to 300°C, would have been the obvious result of optimization. Applicants respectfully submit that there is no suggestion to optimize the temperature of the cold

deposition process step to be within the range of 220 to 300°C, as there is no teaching that a higher temperature is a result effective variable.

> A particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation. *In re Antonie* 195 USPQ 6, (CCPA 1977) (MPEP 2144.05)

In the present case there is no identification of a recognized desired result from adjustment of the temperature and therefore there can be no motivation to optimize the deposition temperature to within the range of 220 to 300°C. Where is the motivation to adjust the temperature range beyond the identified range of below 200°C? What desired result would be achieved by adjustment of the cold deposition temperature to be optimum? Since there is no identified desired result from the cold deposition temperature, as a matter of patent law there is no suggestion to optimize the cold deposition temperature and therefore the claimed temperature range of 220 to 300 °C is not obvious.

In contrast, the present invention is directed to a process in which a seed layer of metal, which may be Al, is formed on a first substrate surface which is Ti, at a substrate temperature of from 220-300°C. The claims recite deposition onto a surface which is Ti, **at a substrate temperature of from 220-300°C** .

As the cited reference provides no disclosure or suggestion of the claimed temperature range of 220 to 300 °C the claimed invention is neither anticipated nor obvious over the cited reference. Withdrawal of the rejection under 35 U.S.C. §103(a) is respectfully requested.

The rejection of Claims 1-21 and 24 under the judicially created doctrine of obviousness-type double patenting over Claims 1-24 of U.S. 6,140,228 and of Claims 22-23 under the judicially created doctrine of obviousness-type double patenting over Claims 1-24 of U.S. 6,140,228 in view of Xu are respectfully traversed.

U.S. '228 does not claim deposition onto **a liner layer which is Ti** nor does it claim deposition of **a seed layer** at a temperature of from 220-300°C. As such, the claimed invention is clearly not obvious under the judicially created doctrine of obviousness-type double patenting as **the claim limitations** of a Ti liner layer and a seed layer deposition temperature of from 220-300°C are **not disclosed or suggested** in the reference. In order to support a rejection for obviousness-type double patenting, there must still be a disclosure or suggestion of each and every claim limitation.

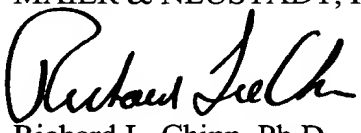
> We decline to extract from Merck the rule that the Solicitor appears to suggest -- that regardless of how broad, a disclosure of a chemical genus renders obvious any species that happens to fall within it. In re Jones 21 USPQ2d 1941 (Fed. Cir. 1992)

The absence of the disclosure or suggestion of the Ti liner layer or the deposition temperature of 220 to 300°C precludes a conclusion of obviousness-type double patenting. Accordingly, withdrawal of the rejection under the judicially created doctrine of obviousness-type double patenting is respectfully requested.

Applicants submit this application is now in condition for allowance and early notification of such action is earnestly solicited.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER & NEUSTADT, P.C.



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